Geographic Variation in the Treatment of Acute Myocardial Infarction
The Cooperative Cardiovascular Project

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EAcH YEAR APPROXIMATELY 1.5 MILLION people in the United States experience acute myocardial infarction (AMI), and approximately one third of these patients die in the acute phase of the AMI. The annual economic burden of AMI is in excess of $60 billion.1 Due to its frequency and severity, AMI has been the topic of intense scientific and clinical interest. Randomized trials have confirmed the efficacy of some therapies resulting in evidence-based treatment guidelines.2,3 These guidelines make it possible to evaluate the processes of care in a meaningful manner and to identify areas for the improvement of the care of patients with AMI.

Since 1992 the Health Care Financing Administration has implemented a continuous quality improvement approach to ensuring the quality of care for its Medicare beneficiaries through its Health Care Quality Improvement Initiative.4 The first national project of this program is the Cooperative Cardiovascular Project (CCP), focusing on the treatment of patients with AMI. Quality indicators, based on clinical practice guidelines, were developed by a steering committee.3 Data on more than 200 000 patients admitted for treatment of AMI were abstracted from clinical records. Patients were classified as eligible or ideal for the specific therapies described by the quality indicators.

During this same time period, studies were conducted to describe the geographic variation of health care in the United States.5 These studies used Medicare

Context Quality indicators for the treatment of acute myocardial infarction include pharmacologic therapy, reperfusion, and smoking cessation advice, but these therapies may not be administered to all patients who could benefit from them.

Objective To assess geographic variation in adherence to quality indicators for treatment of acute myocardial infarction.

Setting Inception cohort using data from the Health Care Financing Administration Cooperative Cardiovascular Project.

Patients A total of 186 800 Medicare beneficiaries hospitalized for treatment of confirmed acute myocardial infarction from February 1994 through July 1995.

Main Outcome Measures Adherence to quality indicators for pharmacologic therapy, reperfusion, and smoking cessation advice for patients judged to be ideal candidates for these therapies. The mean rates of adherence to these quality indicators for the entire United States were determined, and the 20th and 80th percentiles of the age- and sex-adjusted rates for each of 306 hospital referral regions were contrasted (mean rate [20th-80th percentiles]).

Results Aspirin was used frequently both during hospitalization (86.2% [82.6%-90.1%]) and at discharge (77.8% [72.5%-83.9%]). Calcium channel blockers were withheld from most patients with impaired left ventricular function (81.9% [73.6%-90.8%]). Lower rates were seen in the use of angiotensin-converting enzyme inhibitors at discharge (59.3% [49.2%-69.2%]); reperfusion, using thrombolytic therapy or coronary angioplasty (67.2% [59.8%-75.1%]); prescription of β-blockers at discharge (49.5% [35.8%-61.5%]); and for smoking cessation advice (41.9% [32.8%-51.3%]).

Conclusions Substantial geographic variation exists in the treatment of patients with acute myocardial infarction, and these gaps between knowledge and practice have important consequences. Therapies with proven benefit for AMI are underused despite strong evidence that their use will result in better patient outcomes.

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claims data to empirically derive hospital service areas (HSAs), which are local market areas for health care, and hospital referral regions (HRRs). Combining these HRRs with the national sample of data collected by CCP allowed us to study geographic variation in the treatment of AMI in the United States.

## METHODS

### Data Collection

The sampling approach used bills submitted by acute care hospitals (UB-92 claims form data) and contained in the Medicare National Claims History File to identify all Medicare discharges with an International Classification of Diseases, Ninth Revision, Clinical Modification principal diagnosis of 410 (myocardial infarction), excluding fifth digits of 2, which indicate a "subsequent episode of care." Data were collected during 8-month periods, staggered so that all discharge dates were between February 1994 through July 1995. Approximately .003% of the bills submitted could not be linked to medical records. The National Claims History File does not necessarily include bills for all of the approximately 12% of patients treated under Medicare managed care risk contracts. The primary sampling relies on the billing principal diagnosis of AMI. The accuracy of billing diagnoses has been questioned frequently. The criteria for a confirmed AMI required elevated levels of creatine kinase isoenzyme MB or lactate dehydrogenase with LD1 levels greater than LD2 levels or 2 of the following: chest pain, 2-fold elevation of the creatine kinase level, or electrocardiographic evidence of an AMI. This data set contains the 186 800 patients from the 50 states with AMI confirmed by these criteria. There were also 3 special circumstances in the sampling scheme. The pilot states (Alabama, Connecticut, Iowa, and Wisconsin) were sampled initially between June 1 and December 31, 1992, to test the indicator and abstraction methods and then remarried between August 1 and November 30, 1995. Sampling in Minnesota was delayed until April through November 1995 so that it would not interfere with a local study of AMI; only about a 60% sample of AMI diagnoses was included in the CCP study. One hospital that initially ignored record requests was sampled from July 1995 through February 1996. We believe that the sampling strategy used in this study is highly representative of the Medicare fee-for-service patient population in the United States.

### Quality Indicators

Quality indicators are measurable aspects of care that are presumed on the basis of evidence or consensus to be related to the quality of care delivered and to favorable outcomes. They were developed through an intensive review process, be-

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**Table 1. Cooperative Cardiovascular Project Quality Indicators: Eligibility and Exclusion Criteria**

<table>
<thead>
<tr>
<th>Eligibility</th>
<th>Exclusion Criteria</th>
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<tbody>
<tr>
<td>Aspirin prescribed at hospital discharge</td>
<td>All patients with confirmed AMI</td>
</tr>
<tr>
<td>- Exclusions: patients who died or were transferred on the day of admission and those with evidence of bleeding on admission or during the hospitalization; history of bleeding, chronic liver disease, coagulopathy, platelet count &lt;100 x 10^9/L; a serum creatinine level &gt;265 µmol/L (3 mg/dL); history of peptic ulcer disease or a discharge diagnosis of an upper gastrointestinal tract disorder; hemoglobin &lt;100 g/L or hematocrit &lt;0.30; allergy to aspirin; treatment with warfarin sodium on admission; metastatic cancer; or terminal illness</td>
<td></td>
</tr>
<tr>
<td>Aspirin prescribed at hospital discharge</td>
<td>All patients with a confirmed AMI discharged alive and not transferred</td>
</tr>
<tr>
<td>- Exclusions: patients with evidence of bleeding on admission or during the hospitalization; history of bleeding, chronic liver disease, coagulopathy, platelet count &lt;100 x 10^9/L; a serum creatinine level &gt;265 µmol/L (3 mg/dL); history of peptic ulcer disease or a discharge diagnosis of an upper gastrointestinal tract disorder; hemoglobin &lt;100 g/L or hematocrit &lt;0.30; allergy to aspirin; treatment with warfarin; metastatic cancer; or terminal illness</td>
<td></td>
</tr>
<tr>
<td>Reperfusion using either thrombolitics or primary PTCA during first 12 h of hospitalization</td>
<td>All patients with a confirmed AMI and an LVEF &gt;40% discharged alive and not transferred</td>
</tr>
<tr>
<td>- Exclusions: patients without ST-segment elevation or AMI on their admission electrocardiogram; with an onset of chest pain greater than 6 h prior to admission or inadequate documentation of the chest pain; chronic liver disease, history of bleeding, peptic ulcer disease, surgery in the past month, recent trauma, recent cardiopulmonary resuscitation; coagulopathy; any evidence of bleeding on admission; warfarin on admission; a history of stroke; older than 80 y; documentation that thrombolysis was considered but the physician or patient decided against it; or cardiac catheterization performed within 12 h of arrival without PTCA (assumed to be an aborted PTCA)</td>
<td></td>
</tr>
<tr>
<td>β-Blocking agents prescribed at hospital discharge</td>
<td>All patients with a confirmed AMI discharged alive and not transferred</td>
</tr>
<tr>
<td>- Exclusions: good candidates: hypotension or shock during the hospitalization or systolic blood pressure at discharge of &lt;100 mm Hg; history of asthma or chronic obstructive pulmonary disease; bradycardia or pulse at discharge of &lt;50/min (unless discharged and taking a β-blocker); diagnosis of depression or treatment with antidepressants; dementia; conduction disorder including second- or third-degree heart block, bifascicular or trifascicular block; and those at very low risk as documented by no recurrent chest pain, no arrhythmias, no previous AMI, a normal stress test, and no LVEF &lt;50%</td>
<td></td>
</tr>
<tr>
<td>Additional exclusions for ideal candidates: LVEF &lt;35%, pulmonary edema or congestive heart failure (unless measured LVEF &gt;50%), or treatment with insulin</td>
<td></td>
</tr>
<tr>
<td>ACE inhibitors prescribed at hospital discharge</td>
<td>All patients with a confirmed AMI and an LVEF &lt;40% discharged alive and not transferred</td>
</tr>
<tr>
<td>- Exclusions: patients with aortic stenosis; an allergy or intolerance to ACE inhibitor; a serum creatinine level &gt;176 µmol/L (2 mg/dL); or a systolic blood pressure &lt;100 mm Hg at discharge</td>
<td></td>
</tr>
<tr>
<td>Calcium channel blocking agents withheld at hospital discharge in patients with impaired left ventricular function</td>
<td>All patients with a confirmed AMI and an LVEF &lt;40% discharged alive and not transferred</td>
</tr>
<tr>
<td>- Exclusions: patients with atrial fibrillation at any time during the hospitalization; recurrent chest pain; or those receiving calcium channel blockers prior to admission</td>
<td></td>
</tr>
<tr>
<td>Smoking cessation advice given to current cigarette smokers</td>
<td>All cigarette smokers discharged alive and not transferred</td>
</tr>
<tr>
<td>- Exclusions: none</td>
<td></td>
</tr>
<tr>
<td>Documentation in the chart of advice or counseling on smoking cessation</td>
<td>All cigarette smokers discharged alive and not transferred</td>
</tr>
</tbody>
</table>

*AMI indicates acute myocardial infarction; PTCA, percutaneous transluminal angioplasty; LVEF, left ventricular ejection fraction; and ACE, angiotensin-converting enzyme.
ginning with the establishment of a joint Health Care Financing Administration and American Medical Association Steering Committee for the CCP. Indicators were based on treatment guidelines for AMI published by the American College of Cardiology, the American Heart Association, and expert consensus. Representatives from the American College of Cardiology, the American Academy of Family Practice, and the American College of Physicians reviewed and refined these indicators. The peer review organizations in the 4 pilot states further refined the quality indicators and developed data collection instruments and computer algorithms.

For each indicator, specific criteria determined whether a patient could have been a candidate for a particular intervention. Potential candidates were divided into 2 subgroups. Ideal candidates are patients for whom the treatment would almost always be indicated, and less-than-ideal candidates are patients for whom the therapy was controversial (eg, the use of β-blocking agents for patients with congestive heart failure), for whom it was contraindicated (eg, thrombolytics for patients with a recent hemorrhagic stroke), or for whom critical data for determining the appropriateness of the intervention were missing (eg, data on thrombolytic timing were missing). Detailed information on the variable definitions, the indicator algorithms, and the data abstraction software are available at the CCP World Wide Web home page (www.usccp.org).

Data were obtained from the medical record by trained abstractors employed by independent contractors. Quality was monitored and maintained by random reabstractions and the percentage of agreement was generally high (range, 94.8%-98.3%).

Geographic Analysis and Statistical Methods

All Medicare records of hospitalizations of patients residing in the 50 states for 1995 and 1996 were used to assign each ZIP code in the United States to 1 of 3436 geographically distinct HSAs based on where the plurality of patients traveled for hospital care. Based on patterns of care

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for major cardiovascular surgery, HSAs were aggregated into 306 HRRs. The HRRs were empirically derived regional health care markets. The CCP data were mapped to these markets using the ZIP code of the institutional provider of care for each episode of myocardial infarction. Details of the geographic analysis methods have been published. Data from sparsely populated areas were suppressed in these analyses. We also suppressed rates of adherence to specific indicators for any HRR that had less than 11 ideal cases for the indicator.

Quality indicators were evaluated only for patients during their first confirmed AMI during the sampling time frame and who were judged ideal candidates for a specific treatment (Table 1). Rates of adherence to performance indicators (ie, the proportion of ideal patients with confirmed AMI who received the specified treatment) were calculated for each of 306 HRRs. These proportions were adjusted for age and sex using logistic regression analysis. The 20th and 80th percentiles were contrasted as a measure of variability. Standard statistical methods were used for the calculation of the correlation coefficient.

RESULTS
The data set used in these analyses consists of 186,800 patients with confirmed AMI. Figure 1 and Figure 2 show the geographic variation in performance for each of the 7 CCP quality indicators. The white lines on the map are the state boundaries, and the black lines indicate the boundaries of the HRRs. Five levels of color intensity indicate the percentage of ideal patients with confirmed AMI receiving the therapy described by the quality indicator, ranging from white (0%-20% of patients received the therapy) to red (80%-100%). The gray coloring indicates sparsely populated areas or those in which there are insufficient data to calculate meaningful rates. The overall rates of adherence to these quality indicators are summarized in Table 2.

More than 90,000 patients were judged ideal for aspirin therapy, and it was widely prescribed during hospitalization (Figure 1, A). The mean rate was 86.2% (range, 67.8%-100.0%) with 20th and 80th percentiles of 82.6% to 90.1%. No HRRs had rates less than 60%, and the majority were greater than 80%. Most of the HRRs with rates of 60% to 79% were in the south central and southeast regions. Aspirin was prescribed at hospital discharge in 77.8% of the approximately 60,000 patients judged ideal for this therapy (Figure 1, B). The range was...
between 52.1% and 96.0% with 20th and 80th percentiles of 72.5% to 83.9%. Approximately half of the HRRs had rates more than 80%, and only a few were less than 60%. Highest rates were observed in the northeast, north central, and mountain regions.

The quality indicator for reperfusion includes treatment with thrombolytic agents or primary percutaneous transluminal coronary angioplasty during the first 12 hours of hospitalization. The mean rate of reperfusion among 17,071 ideal patients was 67.2% (Figure 1, C). Substantial variation was found with a range from 33.0% to 93.3% and 20th and 80th percentiles of 59.8% to 75.1%. Lowest rates were in the south central and mid Atlantic states with a few HRRs in the west and northwest. Rates greater than 80% were observed in 23 widely scattered HRRs.

There were many exclusions for the use of β-blocking agents, thus only 14,839 (7.9%) of the 186,800 patients with confirmed AMI were judged ideal for this treatment. The large number of HRRs in Minnesota with insufficient data is a consequence of the smaller proportion of AMI patients sampled in that state. Approximately half (49.5%) of all patients judged ideal received β-blocking agents (Figure 2, A). The range was 0%-92.7% with 20th and 80th percentiles of 35.8% to 61.5%. Rates of use of β-blocking agents were highest in the northeast and north central regions and lowest in the south central and south east regions.

Angiotensin-converting enzyme (ACE) inhibitors were prescribed to 59.3% of the approximately 18,000 patients judged ideal for this treatment (Figure 2, B). The range of rates is wide (6.7%-100%) with 20th and 80th percentiles of 49.2% to 69.2%. Rates were somewhat higher in the north central region, but there was no clear geographic pattern of ACE inhibitor use.

The quality indicator for calcium channel blocking agents specifies that they be withheld from patients with impaired left ventricular function (ejection fraction <40%). Since only 4.8% of the patients had this degree of impairment of ventricular function, approximately 25% of HRRs had insufficient data on which to base adherence rates for this quality indicator. Overall, calcium channel blocking agents were withheld from 81.9% of patients for whom their use was contraindicated. There was little variability in rates with 20th and 80th percentiles of 73.6% to 90.8% and no clear geographic pattern (Figure 2, C).

Of the 186,800 patients with confirmed AMI, 22,024 (11.8%) were identified in the clinical record as current cigarette smokers. Of these, 41.9% have documented evidence of smoking cessation advice. The rates of smoking cessation advice varied widely (7.3%-81.7%) with 20th and 80th percentiles of 32.8% to 51.3% (Figure 2, D). Rates were highest in Alaska and the mountain states and lowest in the south central and southeast regions.

To explore the effects of chance, we stratified the 306 HRRs into terciles based on the observed sample size. We calculated the mean and the 20th and the 80th percentiles for small, medium, and large HRRs. These results (not shown) were similar in the small, medium, and large HRRs for every quality indicator. Furthermore, there were only relatively small differences in the 20th and the 80th percentiles of the estimates for the quality indicators.

We also examined the correlation between the various quality indicators by HRR. There was a significant positive correlation between the indicators for treatment with aspirin, β-blocking agents, and ACE inhibitors (r = 0.26-0.59; all P values <.001). Smoking cessation advice was also positively correlated with these indicators (r = 0.16-0.27; all P values <.01). The withholding of calcium channel blocking agents among patients with impaired left ventricular function was weakly and inconsistently related to the other quality indicators. Reperfusion was not significantly correlated with any of the other quality indicators.

**COMMENT**

In these analyses, based on 186,800 patients treated for a confirmed AMI and judged “ideal” for the specific treatment, we found considerable variability in the rates of adherence to the CCP quality indicators. Aspirin was used frequently both during hospitalization (86.2%) and at discharge (77.8%), and calcium channel blocking agents were withheld from most patients with impaired left ventricular function (81.9%). Lower rates were seen in the use of ACE inhibitors at discharge (59.3%), reperfusion using thrombolytic therapy or coronary angioplasty (67.2%), prescription of β-blocking agents at discharge (49.5%), and for documented smoking cessation advice (41.9%). Quality indicators for aspirin, β-blocking agents, ACE inhibitors, and smoking cessation advice were posi-

<table>
<thead>
<tr>
<th>Quality Indicator</th>
<th>No. of Ideal Patients</th>
<th>Mean, %</th>
<th>Range, %</th>
<th>20th-80th Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin prescribed during the hospitalization</td>
<td>96,246</td>
<td>86.2</td>
<td>67.8-100.0</td>
<td>82.6-90.1</td>
</tr>
<tr>
<td>Aspirin prescribed at hospital discharge</td>
<td>60,044</td>
<td>77.8</td>
<td>52.1-96.0</td>
<td>72.5-83.9</td>
</tr>
<tr>
<td>Reperfusion using either thrombolytics or primary PTCA during first 12 h of hospitalization</td>
<td>17,071</td>
<td>67.2</td>
<td>33.0-93.3</td>
<td>59.8-75.1</td>
</tr>
<tr>
<td>β-Blocking agents prescribed at hospital discharge</td>
<td>14,839</td>
<td>49.5</td>
<td>0-92.7</td>
<td>35.8-61.5</td>
</tr>
<tr>
<td>Angiotensin-converting enzyme inhibitors prescribed at hospital discharge</td>
<td>18,114</td>
<td>59.3</td>
<td>6.7-100.0</td>
<td>49.2-69.2</td>
</tr>
<tr>
<td>Calcium channel blocking agents withheld at hospital discharge in patients with impaired left ventricular function</td>
<td>9083</td>
<td>81.9</td>
<td>42.7-100.0</td>
<td>73.6-90.8</td>
</tr>
<tr>
<td>Smoking cessation advice given to current cigarette smokers</td>
<td>22,024</td>
<td>41.9</td>
<td>7.3-81.7</td>
<td>32.8-51.3</td>
</tr>
</tbody>
</table>

*PTCA indicates percutaneous transluminal angioplasty.

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GEOGRAPHIC VARIATION IN ACUTE MYOCARDIAL INFARCTION

Prior studies have shown variability in the treatment of AMI. A wide range of treatment rates by HRR was found for most of the quality indicators. This data set does not have information on any health system characteristics, but the observed geographic variability observed does not support the existence of systematic effects. High and low rates of quality indicators can be found within the same state or region. Although some rather striking regional variations exist, much of the observed variability seems to relate to local clinical practices. It is unlikely that this variation between the care described by the quality indicators and the kind of care actually provided is a consequence of chance or of differences in patient case mix in this large population of patients homogeneous with respect to age, sex, and access to health care.

There are 2 limitations to these data and the inferences that can be drawn from this study. First, these data rely on information contained in the medical record. Medical records are sometimes illegible or poorly organized, and the task of medical record abstraction is quite difficult. Reliability testing of the medical record abstraction in the CCP study has shown excellent interrater reliability. While it is possible that variations noted were due to care that was provided and not documented, this would suggest a significant departure from established documentation policies. In all hospitals, it is required that physician orders be recorded in the medical record for specific therapies to be administered, and documentation of discharge medications is required by the Joint Commission on Healthcare Organizations. Thus, we believe that the CCP data abstraction system yields an overall accurate representation of the care of these patients. Second, the patterns of geographic variation in the treatment of AMI observed in this national study may accurately represent care during this study period but may not represent long-term patterns of care.

Prior studies have shown variability in use of medical and surgical services. Studies of treatment of AMI have evaluated variability in the use of diagnostic and therapeutic procedures among specific patient subgroups, by payers, or by location. Studies of specific medical therapies have been far less frequent. Pilot et al studied regional variation in the management of AMI in the United States among 21,772 patients and found substantial variation in the use of medications and in invasive procedures. Rogers et al reported observations from the National Registry of Myocardial Infarction and concluded that there was substantial underuse of thrombolytic therapy and β-blocking agents and substantial overuse of calcium channel blockers.

Reports from randomized trials or voluntary registries may not represent the care provided for the entire United States. The CCP results describe AMI care for patients with AMI participating in the Medicare fee-for-service program. These findings are in general agreement with the conclusions reached by Pilot et al and Rogers et al and extend the findings of these studies by identifying patients ideal for the specific therapy and demonstrating variation in compliance to guidelines throughout the United States. This study shows the opportunity for improvement of the care of patients with AMI using existing knowledge. Aspirin, β-blockers, ACE inhibitors, and thrombolytics have been shown in randomized trials to reduce mortality due to AMI. Reperfusion using percutaneous transluminal coronary angioplasty has been shown to have a protective effect on short-term mortality after AMI. The American College of Cardiology and American Heart Association guidelines have listed primary percutaneous transluminal coronary angioplasty as an alternative to thrombolytic therapy. In these CCP data, substantial numbers of patients judged ideal for these treatments did not receive them. Approximately 14% of such patients did not receive aspirin during hospitalization, 22% did not receive aspirin at discharge, 50% did not receive β-blocking agents, 41% did not receive ACE inhibitors, and 33% did not receive reperfusion. Calcium channel blocking agents were administered to 18.1% of patients with impaired left ventricular function.

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The circle of science which I have run through, before I undertook the study of physic, is not only useful but absolutely necessary to the making of a skilful physi-
cian. Such sciences enlarge our understanding, and sharpen our sagacity; and what is a practitioner with-
out both but an empiric, for never yet was a disorder found entirely the same in two patients?
—Oliver Goldsmith (1728-1774)